CLAIMS

What is claimed is:

1. A high throughput hole forming system with multiple spindles per spindle station, comprising:

a base table;

a work piece table for supporting work pieces under process;

a first drive system for moving the work piece table along a Y axis in relation to the base table;

a plurality of spindle stations;

a first set of spindles, each for holding a hole forming tool, comprising a first spindle at each said spindle station;

a second set of spindles, comprising a second spindle at each said spindle station;

a first spindle linear drive system for commonly driving said first set of spindles along an X axis which is orthogonal to said Y axis;

a second spindle linear drive system for commonly driving said second set of spindles along the X axis; and

Z axis drive system for driving said spindles along a Z axis which is orthogonal to said X and Y axis.

2. The system of Claim 1 further comprising a controller for controlling said Y axis, X axis and Z axis drive systems to conduct hole forming operations on a plurality of work pieces located at respective ones of said spindle stations, such that a first spindle of said first set and a first spindle of said second set is operated to conduct hole forming operations simultaneously on a single work piece.

3. The system of Claim 1 wherein said first set of spindles and said second set of spindles are arranged on a common plane which is orthogonal to said work piece table.

4. The system of Claim 1 wherein spindles of said first set are interleaved along the X axis with spindles of the second set.

5. The system of Claim 1 wherein said first spindle linear drive includes:

a linear bearing for supporting a first set of spindle slides for motion along the X axis, each slide supporting a corresponding one of said first spindle set;

a first bar structure rigidly attached to each slide of said first slide set to gang together said first set of slides in a spaced relationship on said linear bearing for motion as a first ganged set along the linear bearing; and

a first linear force applying structure for moving the first ganged set along the X axis.

6. The system of Claim 5 wherein said first linear force applying structure includes a servo motor coupled to a leadscrew, and a leadscrew nut threaded onto the lead-screw and secured to said first ganged set.

7. The system of Claim 6 wherein said leadscrew nut is secured to one slide of said first set of slides.

8. The system of Claim 5 wherein said first linear force applying structure includes a linear motor drive system including a set of stationary permanent magnets extending along the X axis and a coil attached to said first ganged set.

9. The system of Claim 5 wherein said linear bearing further supports a second set of spindle slides for motion along the X axis, each slide of said second slide set supporting a corresponding spindle of said second spindle set, and wherein second spindle linear drive further includes:

a second bar structure rigidly attached to each slide of said second slide set to gang together said second set of slides in a spaced relationship on said linear bearing for motion as a ganged set along the linear bearing; and

a second linear force applying structure for moving the second ganged set along the X axis.

10. The system of Claim 5 wherein said linear bearing includes first and second linear guiding rails secured to an overhead beam supported over said work piece table, and, for each slide, a plurality of bearing slide members each attached to said slide and constrained for sliding movement along one of said linear guiding rails.

11. A hole forming system for forming holes in a work piece under automated control, comprising:

a base table;

a work piece table for supporting work pieces under process;

a Y axis drive system for moving the work piece table along a Y axis in relation to the base table;

a spindle including a rotary drive for rotating a tool at very high speed during hole forming operations;

an X axis drive system for driving said spindle along an X axis which is orthogonal to said Y axis;

Z axis drive system for driving said spindle along a Z axis which is orthogonal to said X and Y axis;

a tool changer for holding one or more drilling tools and a router tool for selective use in the spindle during hole forming operations;

a controller for controlling the X axis, Y axis and Z axis drive systems, said spindle rotary drive and said tool changer for selecting an appropriate tool for hole forming operations and executing said hole forming operations, wherein said system is controlled to use a drilling tool to form holes having an outer diameter under a predetermined threshold diameter by rotating the drilling tool at very high speed and feeding the drilling tool into and out of the work piece along a single Z axis, and to use a router tool to form holes having an outer diameter exceeding the threshold diameter by a routing movement.

12. The system of Claim 11 wherein said spindle is capable of rotary spindle rates of 150,000 revolutions per minute.

13. The system of Claim 12 wherein said predetermined threshold diameter is about 0.125 inches.

14. The system of Claim 11 wherein said routing movement includes a spiral movement of the rotating router in a plane transverse to the Z axis.

15. The system of Claim 11 wherein a single router tool is employed to form all holes having a diameter exceeding said threshold diameter, thereby minimizing tool changes.

16. A method for forming holes in a work piece, comprising a sequence of the following steps:

providing a spindle capable of very high rotational drive rates and a linear drive, for rotating a tool and feeding the tool into and out of a work piece;

providing a selection of tools including a set of drilling tools of various diameters, and at least one router tool;

using one or more tools of the set of drilling tools to drill a set of holes in a work piece having diameters less than a predetermined threshold diameter size; and

using said router tool to form one or more holes of diameters larger than the threshold diameter in a routing operation.

17. The method of Claim 16 wherein said routing operation includes feeding the rotating router tool into the work piece, with the tool still rotating in the work piece, providing relative movement between the tool and the work piece to move the router tool through a path transverse to the spindle axis.

18. The method of Claim 17 wherein the transverse path is a spiral path.

19. The method of Claim 16 wherein said spindle is capable of rotary spindle rates of 150,000 revolutions per minute.

20. The method of Claim 19 wherein said predetermined threshold diameter is about 0.125 inches.

21. A hole forming system for forming holes in a plurality of work pieces, comprising:

a base table;

an elongated work piece table for simultaneously supporting a plurality of work pieces distributed along a longitudinal extent of the work piece table;

a bearing system for supporting the work piece table for constrained movement of the work piece table along a first axis which is transverse to said longitudinal extent;

a table drive system for driving the work piece table along the first axis under computer control;

the bearing system including first and second outrigger bearings for supporting the work piece table at respective outrigger positions adjacent opposite ends of the table, and respective first and second flexure mount structures for coupling the work piece table to the first and second bearings, said flexure mount structures for providing stiffness in directions transverse to said first axis while having flexibility for displacement along the first axis in response to stress forces directed along the longitudinal extent, thereby relieving forces resulting from differential thermal coefficients of expansion of the respective table or bearing misalignment.

22. The system of Claim 21 wherein said bearing system includes first and second linear guiding rails attached to said base table and extending in parallel to the first axis, and first and second bearing slides attached to said flexure mount structures for respectively engaging the first and second rails.

23. The system of Claim 21 wherein the flexure structures each comprise an integral structure formed of a

springy material, the structure having a cross-section configuration in the general form of an I, wherein top and bottom web portions are connected by a middle web portion, and wherein the middle web portion has first and second spaced regions of reduced thickness, wherein the flexure structures are flexible at said regions of reduced thickness.

24. A high throughput hole forming system with multiple spindles per spindle station, comprising:

a base table;

a work piece table for supporting work pieces under process;

a first drive system for moving the work piece table along a Y axis in relation to the base table;

a plurality of spindle stations;

a plurality of sets of spindles, each spindle for holding a hole forming tool, each set including a spindle at each said spindle station, each set of spindles bearing mounted on a common linear bearing for linear movement along an X axis which is transverse to said Y axis, the spindles of each set commonly connected together to form a ganged set;

a plurality of computer-controllable spindle linear drive systems each for commonly driving a set of said spindles along said X axis; and

Z axis drive system for individually driving said spindles along a Z axis which is transverse to said X and Y axis.

25. The system of Claim 24 further comprising a controller for controlling said drive systems to conduct hole forming operations on a plurality of work pieces located at respective ones of said spindle stations, such that a spindle of each set is operated to conduct hole

forming operations simultaneously on a single work piece at a given station.

26. The system of Claim 24 further comprising adjustable mounting structure for mounting each spindle to said bearing system to align each spindle in the Z and X axis.